SPECIFICATION
FOR
APPROVAL

( ) Preliminary Specification
(●) Final Specification

Title	24.0" WUXGA TFT LCD

BUYER	
MODEL	

SUPPLIER	LG Display Co., Ltd.
*MODEL	LM240WU5
SUFFIX	SLA1

*When you obtain standard approval,
please use the above model name without suffix

APPROVED BY	SIGNATURE DATE
/	
/	
/	

Please return 1 copy for your confirmation with your signature and comments.

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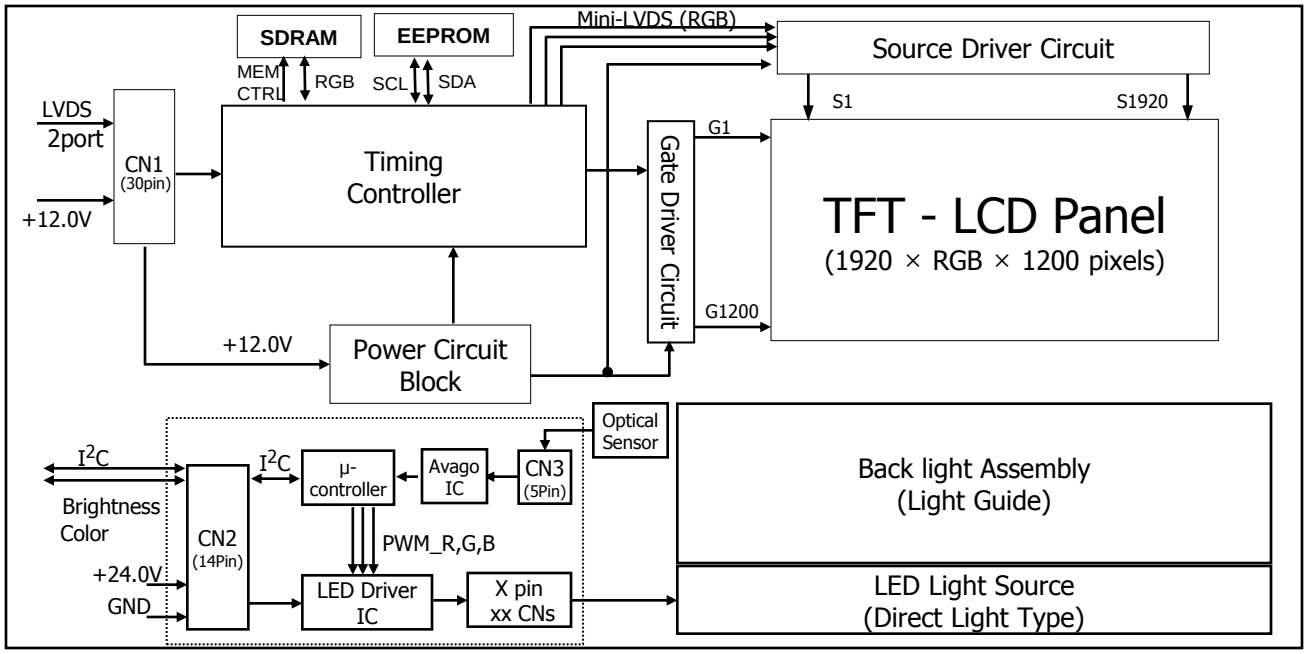
RECORD OF REVISIONS

Revision No	Revision Date	Page	Description
0.0	Mar. 05. 2007	-	First Draft(Preliminary)
0.1	May. 15. 2007	1	Block diagram update (add SDRAM, EEPROM)
			LCM Thickness (TBD→48.4mm), Weight (TBD→ 3300g)
			Weight (TBD→ 3300g)
		7	LED Driver Electrical characteristic update
		11	Timing Clock change
		21	Add fig.4 25% box size
		24	Weight (TBD→ 3300g), LCM Depth (TBD→48.4mm)
0.2	Aug. 31. 2007	2	Page update
		4,6	Power Consumption update
		7	LED and driver electrical characteristics update
		10	Backlight on/off voltage change
		11,12	Time specification update for 60Hz,50Hz & 48Hz
		16	LED Driver Power Sequence update
		18	Surface luminance and color coordinate spec update
		18,19,21	Add the Gray to Gray time
		21	Update for Color Shift Table
		23	Update for Gray Scale
		24	LCM Max. Weight update & Bezel open Dim. Error debugging
		26	Rear view drawing of LCM update
		29	Packing form information update
0.3	Sep. 12. 2007	18	Correcting the GX,GY color coordinate spec
0.4	Oct. 05. 2007	8	Connector description change from LS Cable to JAE
		28	International Standard update
0.5	Nov. 27. 2007	10	CNT change (B14B-PH-SM3 : JST→ 20022WS-14AM : YEONHO)
		18	Correcting the Gx,Gy, By color coordinate spec
		26	Rear View Drawing update
0.6	Feb, 11, 2008	8	LED and Driver Electrical Characteristics update
		7	Pin No 2, ODC ON/OFF Selection function adding
		10	LED Driver Connector : Removing the Equivent connector
		19	Green Color Coordinates update
		26	Rear View Drawing update
		27	Vibration test Spec correction
1.0	March, 07, 2008	-	First Draft (Final)
		15	Adding ODC ON/OFF Sequence

1. General Description

LM240WU5 is a Color Active Matrix Liquid Crystal Display with Light Emitting Diode(LED) backlight system. The matrix employs a-Si Thin Film Transistor as the active element. It is a transmissive type display operating in the normally black mode. It has a 24inch diagonally measured active display area with WUXGA resolution (1200 vertical by 1920 horizontal pixel array) Each pixel is divided into Red, Green and Blue sub-pixels or dots which are arranged in vertical stripes. Gray scale or the brightness of the sub-pixel color is determined with a 10-bit gray scale signal for each dot, thus, presenting a palette of more than 1.073G(True) colors.
It has been designed to apply the 10Bit 2 port LVDS interface.
It is intended to support displays where high brightness, super wide viewing angle, high color saturation, and high color are important.



General Features

Active Screen Size	24.0 inches(60.96cm) diagonal
Outline Dimension	546.4(H) x 352.0(V) x 48.4(D) mm(Typ.)
Pixel Pitch	0.270 mm x 0.270 mm
Pixel Format	1920 horiz. By 1200 vert. Pixels RGB stripes arrangement
Color Depth	10-bit, 1,073,741,824 colors
Luminance, White	250 cd/m^2 (Typ.)
Viewing Angle(CR>10)	View Angle Free (R/L 178(Typ.), U/D 178(Typ.))
Power Consumption	Total 56.96Watt (Typ.) (6.96Watt @V_{LCD}, 50 Watt @250cd)
Weight	3,300g (typ.)
Display Operating Mode	Transmissive mode, normally black
Surface Treatment	Hard coating(3H), anti-glare treatment of the front polarizer

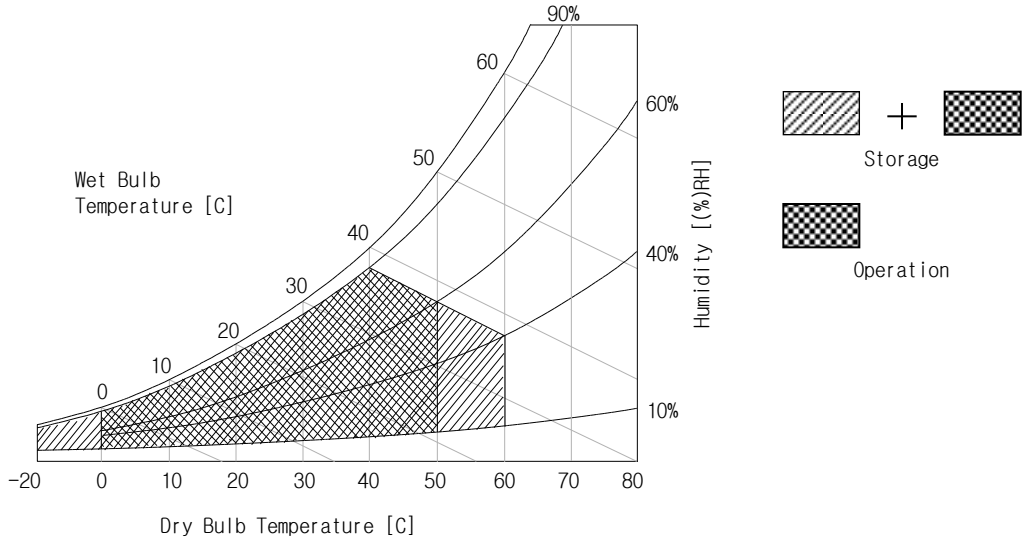
2. Absolute Maximum Ratings

The following are maximum values which, if exceeded, may cause faulty operation or damage to the unit.

Table 1. ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Values		Units	Notes
		Min	Max		
Power Input Voltage	VLCD	8	14	Vdc	at 25 ± 2°C
Operating Temperature	TOP	0	50	°C	1
Storage Temperature	TST	-20	60	°C	
Operating Ambient Humidity	HOP	10	90	%RH	
Storage Humidity	HST	10	90	%RH	

Note : 1. Temperature and relative humidity range are shown in the figure below.
Wet bulb temperature should be 39 °C Max, and no condensation of water.



3. Electrical Specifications

3-1. Electrical Characteristics

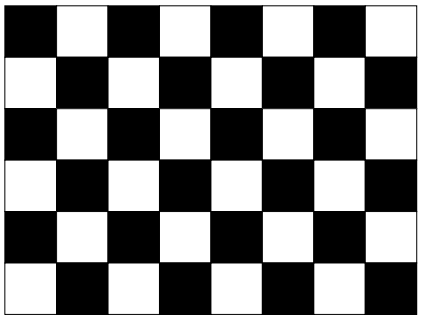
It requires two power inputs. One is employed to power the LCD electronics and to drive the TFT array and liquid crystal. The second input power for the LED, is typically generated by an LED driver. The LED driver is an external unit to the LCDs.

Table 2-1. ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Values			Unit	Notes
		Min	Typ	Max		
MODULE :						
Power Supply Input Voltage	V_{LCD}	11.4	12.0	12.6	Vdc	
Permissive Power Input Ripple	V_{dRF}			400	mV_{p-p}	
Power Supply Input Current	I_{LCD}	527	580	713	mA	1
		637	750	862	mA	2
Power Consumption	P_{LCD}	-	6.96	8.0	Watt	1
Rush current	I_{RUSH}	-	-	3.0	A	3

Note :
1. The specified current and power consumption are under the V_{LCD}=12.0V, 25 ± 2°C,f_V=60Hz condition whereas mosaic pattern(8 x 6) is displayed and f_V is the frame frequency.
2. The current is specified at the maximum current pattern.
3. The duration of rush current is about 2ms and rising time of power Input is 1ms(min.).

White : 1023Gray
Black : 0Gray



Mosaic Pattern(8 x 6)

Table 2-2. LED AND DRIVER ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Condition	Values			Unit	Notes
			Min.	Typ.	Max.		
LED driver :							
Input Voltage	Vin	-	21.6	24	26.4	V	1
Input Current	Iin	-	-	2.1	-	A	2
Input Power	Pin	-	-	50	60	W	2
Backlight On/Off Control	Von/off	ON=High	3.0	-	5.0	V	
		OFF=Low	0.0	-	0.8	V	
Output Voltage	Vout	Red	-	86	-	Vpeak	3
		Green	-	133	-	Vpeak	
		Blue	-	136	-	Vpeak	
Output Current	I_red		-	20	-	mApeak	100% Duty Cycle
	I_green		-	25	-	mApeak	
	I_blue		-	19	-	mApeak	
Brightness Control	Beta	Address : 0xC4	50	-	255	8bit	I2C Data
PWM Frequency	Freq	Frame Rate : 48Hz	-	144	-	Hz	
		Frame Rate : 50Hz		150			
		Frame Rate : 60Hz		180			
LED							
LED String Voltage	Red Vs			90	102	V	4
	Green Vs			129	144	V	
	Blue Vs			138	153	V	
LED Life Time	Red_LT		50,000	-	-	Hrs	5
	Green_LT		50,000	-	-	Hrs	
	Blue_LT		50,000	-	-	Hrs	

Notes :

1. The input voltage ripple is limited below 400mVp-p.
2. The specified current and power consumption are under the typical supply Input voltage, 24V.
3. Duty cycle is LCM level measurement
4. Electrical specifications defined on DC red 20mA, green 25mA and blue 20mA.
   (Measurement condition : after turn on 5 sec, Ta=25° C ±2)
5. The life time is determined as the time at which luminance of the LCM is 50% compared to that of initial value at the typical LED current on condition of continuous operating at 25 ± 2°C.

3-2. Interface Connections

3-2-1. LCD Module

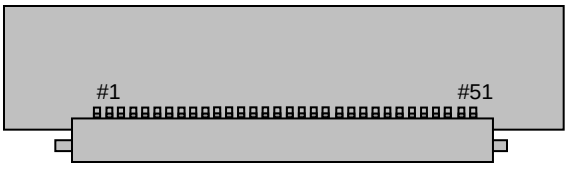
- LCD Connector(CN1). : FI-RE51S-HF (Manufactured by JAE) or equivalent
- Mating Connector: FI-RE51HL (Manufactured by JAE) or equivalent

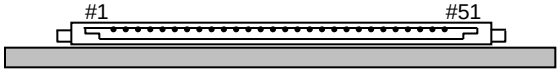
Table 3 MODULE CONNECTOR(CN1) PIN CONFIGURATION

No	Symbol	Description	No	Symbol	Description
1	GND	Ground	27	GND	Ground
2	ODC ON/OFF	Low : ODC OFF, H or OPEN : ODC ON	28	RE0N	SECOND CHANNEL 0-
3	NC	Reserved	29	RE0P	SECOND CHANNEL 0+
4	NC	(I2C DATA Interface)	30	RE1N	SECOND CHANNEL 1-
5	NC	(I2C CLK Interface)	31	RE1P	SECOND CHANNEL 1+
6	NC	(EEPROM Write Protection)	32	RE2N	SECOND CHANNEL 2-
7	LVDS Select	'L' : LG(NS) , 'H': DISM format	33	RE2P	SECOND CHANNEL 2+
8	GND	Ground	34	GND	Ground
9	GND	Ground	35	RECLKN	SECOND CLOCK CHANNEL C-
10	GND	Ground	36	RECLKP	SECOND CLOCK CHANNEL C+
11	GND	Ground	37	GND	Ground
12	RO0N	FIRST CHANNEL 0-	38	RE3N	SECOND CHANNEL 3-
13	RO0P	FIRST CHANNEL 0+	39	RE3P	SECOND CHANNEL 3+
14	RO1N	FIRST CHANNEL 1-	40	RE4N	SECOND CHANNEL 4-
15	RO1P	FIRST CHANNEL 1+	41	RE4P	SECOND CHANNEL 4+
16	RO2N	FIRST CHANNEL 2-	42	GND	Ground
17	RO2P	FIRST CHANNEL 2+	43	GND	Ground
18	GND	Ground	44	GND	Ground (NSB)
19	ROCLKN	FIRST CLOCK CHANNEL C-	45	GND	Ground
20	ROCLKP	FIRST CLOCK CHANNEL C+	46	GND	Ground
21	GND	Ground	47	NC	NC
22	RO3N	FIRST CHANNEL 3-	48	VLCD	Power Supply +12.0V
23	RO3P	FIRST CHANNEL 3+	49	VLCD	Power Supply +12.0V
24	RO4N	FIRST CHANNEL 4-	50	VLCD	Power Supply +12.0V
25	RO4P	FIRST CHANNEL 4+	51	VLCD	Power Supply +12.0V
26	GND	Ground	-	-	-

Note: 1. All GND(ground) pins should be connected together and should also be connected to the LCD's metal frame.
2. All V_{LCD} (power input) pins should be connected together.
3. Input Level of LVDS signal is based on the IEA 664 Standard.

User Connector Diagram





Rear view of LCM

Table 4. REQUIRED SIGNAL ASSIGNMENT FOR Flat Link (TI:SN75LVDS83) Transmitter

Pin #	Pin Name	Require Signal	Pin #	Pin Name	Require Signal
1	Vcc	Power Supply for TTL Input	29	GND	Ground pin for TTL
2	D5	TTL Input (R7)	30	D26	TTL Input (DE)
3	D6	TTL Input (R5)	31	T_X CLKIN	TTL Level clock Input
4	D7	TTL Input (G0)	32	PWR DWN	Power Down Input
5	GND	Ground pin for TTL	33	PLL GND	Ground pin for PLL
6	D8	TTL Input (G1)	34	PLL Vcc	Power Supply for PLL
7	D9	TTL Input (G2)	35	PLL GND	Ground pin for PLL
8	D10	TTL Input (G6)	36	LVDS GND	Ground pin for LVDS
9	Vcc	Power Supply for TTL Input	37	TxOUT3+	Positive LVDS differential data output 3
10	D11	TTL Input (G7)	38	TxOUT3−	Negative LVDS differential data output 3
11	D12	TTL Input (G3)	39	T_X CLKOUT+	Positive LVDS differential clock output
12	D13	TTL Input (G4)	40	T_X CLKOUT−	Negative LVDS differential clock output
13	GND	Ground pin for TTL	41	T_X OUT2+	Positive LVDS differential data output 2
14	D14	TTL Input (G5)	42	T_X OUT2−	Negative LVDS differential data output 2
15	D15	TTL Input (B0)	43	LVDS GND	Ground pin for LVDS
16	D16	TTL Input (B6)	44	LVDS Vcc	Power Supply for LVDS
17	Vcc	Power Supply for TTL Input	45	T_X OUT1+	Positive LVDS differential data output 1
18	D17	TTL Input (B7)	46	T_X OUT1−	Negative LVDS differential data output 1
19	D18	TTL Input (B1)	47	T_X OUT0+	Positive LVDS differential data output 0
20	D19	TTL Input (B2)	48	T_X OUT0−	Negative LVDS differential data output 0
21	GND	Ground pin for TTL Input	49	LVDS GND	Ground pin for LVDS
22	D20	TTL Input (B3)	50	D27	TTL Input (R6)
23	D21	TTL Input (B4)	51	D0	TTL Input (R0)
24	D22	TTL Input (B5)	52	D1	TTL Input (R1)
25	D23	TTL Input (RSVD)	53	GND	Ground pin for TTL
26	Vcc	Power Supply for TTL Input	54	D2	TTL Input (R2)
27	D24	TTL Input (HSYNC)	55	D3	TTL Input (R3)
28	D25	TTL Input (VSYNC)	56	D4	TTL Input (R4)

Notes : Refer to LVDS Transmitter Data Sheet for detail descriptions.

3-2-2. Backlight Interface

-LED driver Connector : 20022WS-14AM Top entry type (Manufactured by YEONHO)

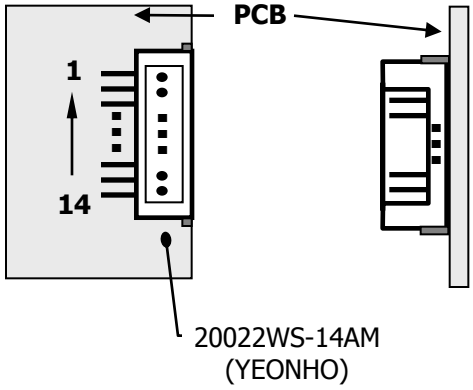
- Mating Connector : PHR-14(Manufactured by JST) or Equivalent

Table 4. LED driver CONNECTOR PIN CONFIGULATION

Pin No	Symbol	Description	Remarks
1	V_{BL}	Power Supply +24.0V	
2	V_{BL}	Power Supply +24.0V	
3	V_{BL}	Power Supply +24.0V	
4	V_{BL}	Power Supply +24.0V	
5	OPEN	NC	
6	GND	Power Ground	Note 1
7	GND	Power Ground	
8	GND	Power Ground	
9	GND	Power Ground	
10	OPEN	NC	
11	V_{ON}	Backlight On/off Signal	(On :3.0V~5V/Off :0.0~0.8V)
12	GND	I2C Ground	
13	SCL	I2C clock	Note 2
14	SDA	I2C data	

Notes : 1. GND is connected to the LCD's metal frame.
2. Luminance and color can be control by I2C

Rear view of LCM



3-3-1. Signal Timing Specifications

This is signal timing required at the input of the LVDS transmitter. All of the interface signal timing should be satisfied with the following specifications for it's proper operation.

Table 5. TIMING TABLE for Frame Rate 60Hz

ITEM		SYMBOL	MIN	TYP	MAX	UNIT	NOTE
DCLK	Period	tCLK	12.82	12.98	13.16	ns	Pixel Frequency Typical 154MHz (2Pixel/clk)
	Frequency	fCLK	75	77	78	MHz	
Hsync	Period	tHP	1024	1040	1060	tCLK	
	Width-Active	tWH	16	16	16		
Vsync	Period	tVP	1225	1235	1250	tHP	
	Frequency	fV	58.72	59.95	61.46	Hz	
	Width-Active	tWV	6	6	6	tHP	
Data Enable	Horizontal Valid	tHV	960	960	960	tCLK	
	Horizontal Back Porch	tHBP	32	40	60		
	Horizontal Front Porch	tHFP	16	24	44		
	Horizontal Blank	-	64	80	100		tWH+ tHBP+ tHFP
	Vertical Valid	tVV	1200	1200	1200	tHP	
	Vertical Back Porch	tVBP	18	26	42		
	Vertical Front Porch	tVFP	2	3	19		
	Vertical Blank	-	26	35	50		tWV+ tVBP+ tVFP

Note: Hsync period and Hsync width-active should be even number times of tCLK. If the value is odd number times of tCLK, display control signal can be asynchronous. In order to operate this LCM a Hsync, Vsyn, and DE(data enable) signals should be used.

1. The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rates.
2. Vsync and Hsync should be keep the above specification.
3. Hsync Period, Hsync Width, and Horizontal Back Porch should be any times of of character number(8).
4. The polarity of Hsync, Vsync is not restricted.

3-3-2. Signal Timing Specifications

This is signal timing required at the input of the LVDS transmitter. All of the interface signal timing should be satisfied with the following specifications for it's proper operation.

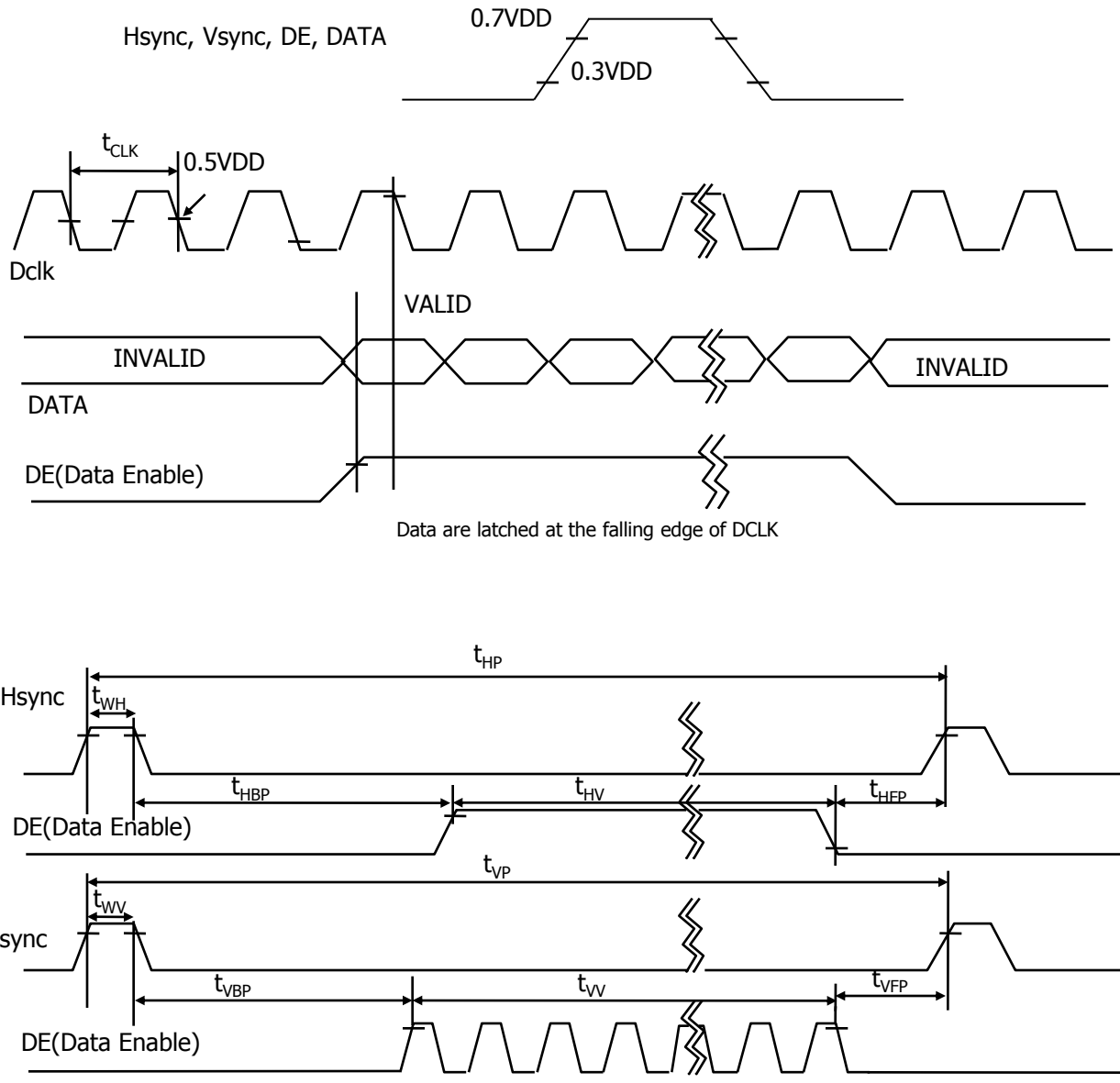
Table 5. TIMING TABLE for Frame Rate 48Hz/50Hz

ITEM		SYMBOL	MIN	TYP	MAX	UNIT	NOTE
DCLK	Period	tCLK	15.88	16.04	16.94	ns	Pixel Frequency Typical 122.5MHz (2Pixel/clk)
	Frequency	fCLK	59	61.25	65	MHz	
Hsync	Period	tHP	1024	1040	1060	tCLK	
	Width-Active	tWH	16	16	16		
Vsync	Period	tVP	1225	1228	1250	tHP	
	Frequency	fV	46.2	47.959	51.6	Hz	
	Width-Active	tWV	6	6	6	tHP	
Data Enable	Horizontal Valid	tHV	960	960	960	tCLK	
	Horizontal Back Porch	tHBP	32	40	60		
	Horizontal Front Porch	tHFP	16	24	44		
	Horizontal Blank	-	64	80	100		tWH+ tHBP+ tHFP
	Vertical Valid	tVV	1200	1200	1200	tHP	
	Vertical Back Porch	tVBP	18	26	42		
	Vertical Front Porch	tVFP	2	3	19		
	Vertical Blank	-	26	28	50		tWV+ tVBP+ tVFP

Note: Hsync period and Hsync width-active should be even number times of tCLK. If the value is odd number times of tCLK, display control signal can be asynchronous. In order to operate this LCM a Hsync, Vsyn, and DE(data enable) signals should be used.

1. The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rates.
2. Vsync and Hsync should be keep the above specification.
3. Hsync Period, Hsync Width, and Horizontal Back Porch should be any times of of character number(8).
4. The polarity of Hsync, Vsync is not restricted.

3-4. Signal Timing Waveforms



3-5. Color Data Reference

The Brightness of each primary color(red,green,blue) is based on the 10-bit gray scale data input for the color; the higher the binary input, the brighter the color. The table below provides a reference for color versus data input.

Table 6. COLOR DATA REFERENCE

Color		Input Color Data																													
		RED										GREEN										BLUE									
		MSB									LSB	MSB									LSB	MSB									LSB
		R9	R8	R7	R6	R5	R4	R3	R2	R1	R0	G9	G8	G7	G6	G5	G4	G3	G2	G1	G0	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
Basic Color	Black	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Red (1023)	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Green (1023)	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
	Blue (1023)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
	Cyan	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Magenta	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1
	Yellow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
	White	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
RED	RED (000)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RED (001)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	...					...										...										...					
	RED (1022)	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RED (1023)	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GREEN	GREEN (000)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	GREEN (001)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	...					...										...										...					
	GREEN (1022)	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
	GREEN (1023)	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
BLUE	BLUE (000)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	BLUE (001)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	...					...										...										...					
	BLUE (1022)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0
	BLUE (1023)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1

3-6. Power Sequence

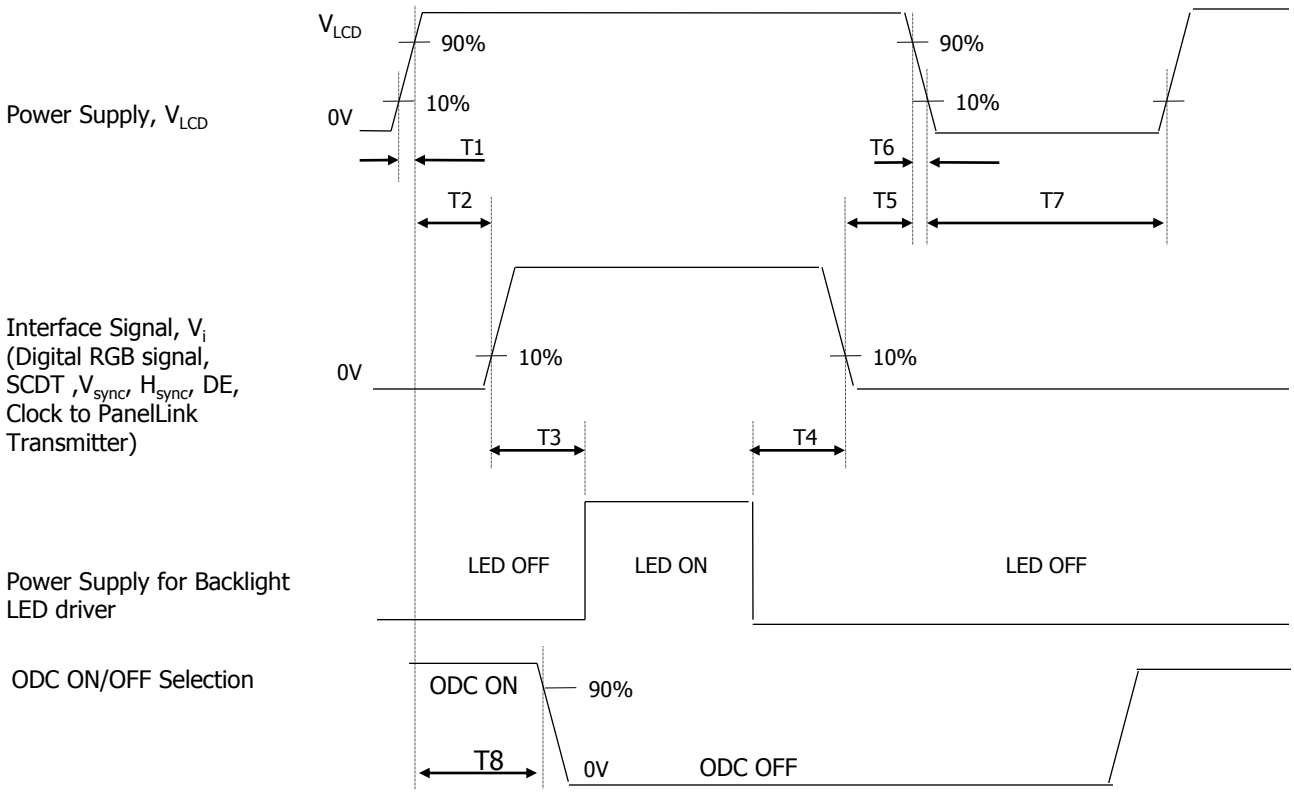


Table 7. POWER SEQUENCE

Parameter	Values			Units
	Min	Typ	Max	
T1	1.0	-	10	ms
T2	0.01	-	50	ms
T3	200	-	-	ms
T4	200	-	-	ms
T5	0.01	-	50	ms
T6	0.01	-	10	ms
T7	1		-	s
T8	93.35			ms

Notes : 1. Please avoid floating state of interface signal at invalid period.
2. When the interface signal is invalid, be sure to pull down the power supply for LCD $V_{LCD}$to 0V.
3. Lamp power must be turn on after power supply for LCD and interface signal are valid.

3-7. Power Sequence for LED driver

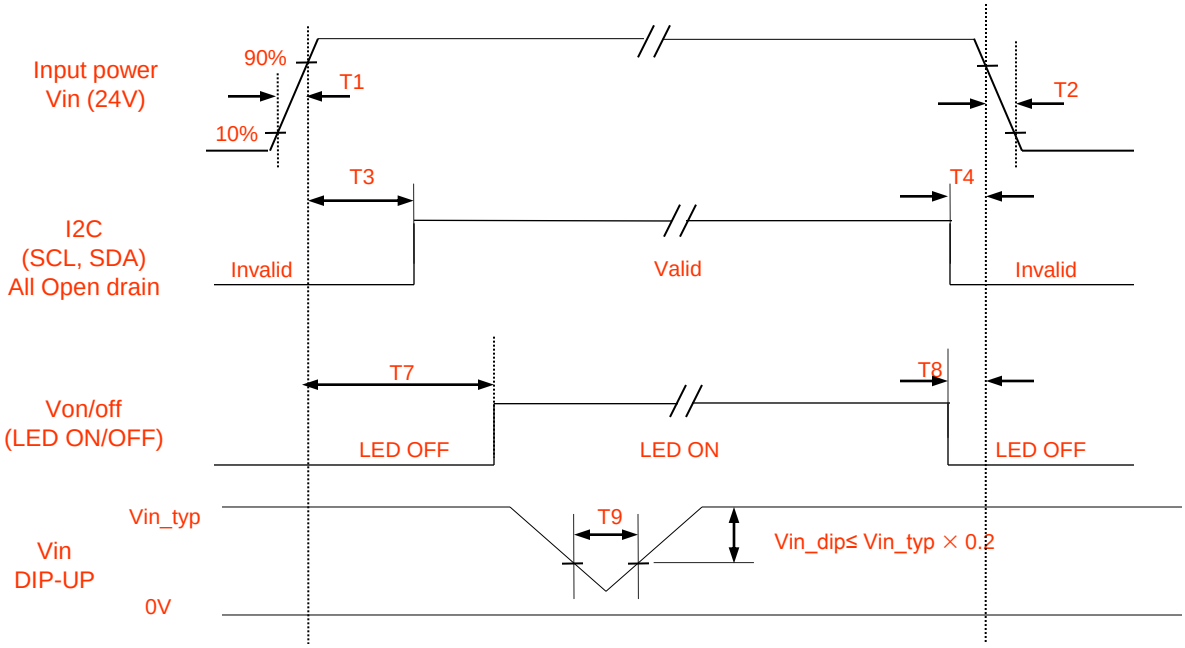


Table 8. POWER SEQUENCE

Parameter	Values			Units	Notes
	Min.	Typ.	Max.		
T1	30	-	50	ms	
T2	-	-	100	ms	
T3	700	-	-	ms	
T4	100	-	-	ms	
T7	900	-	-	ms	
T8	100	-	-	ms	
T9	-	-	0.5	ms	Open-loop

3-8. Back light control Protocol for LED driver

Table9. Sequence for Back light control

Step	I2C data Sequence	Comments
1	S[0x6A][0x04][0x02]P	Select Yxy color space
2.1	S[0x6A][0x18][B_lo]P, S[0x6A][0x19][B_hi]P	Send B value for Wx change
2.2	S[0x6A][0x1A][C_lo]P, S[0x6A][0x1B][C_hi]P	Send C value for Wy change
2.3	S[0x6A][0xC4][Beta]P	Send Beta value for Luminance change
2.4	S[0x6A][0x01][0x12]P	Update new set point
3.1	S[0xA0][0x18][B_lo]P, S[0xA0][0x19][B_hi]P	Save B value to EEPROM for initial Wx value
3.2	S[0xA0][0x1A][C_lo]P, S[0xA0][0x1B][C_hi]P	Save C value to EEPROM for initial Wy value
3.3	S[0xA0][0xC4][Beta]P	Save Beta value to EEPROM for initial Luminance value

Table 10. Protocol for Back light control

Address		Register	Description	Reset Value
Decimal	Hex			Hex
27	0x1B	COLOR_SETC_HI	User color set point C. Upper 2 bits	0x00
26	0x1A	COLOR_SETC_LO	User color set point C. Lower 8 bits	0x00
25	0x19	COLOR_SETB_HI	User color set point B. Upper 2 bits	0x00
24	0x18	COLOR_SETB_LO	User color set point B. Lower 8 bits	0x00
196	0xC4	BETA	Brightness Control. 8 bits	0xFF

❑ NORMAL MODE OPERATION ONLY

4. Optical Specifications

Optical characteristics are determined after the unit has been 'ON' for approximately 30 minutes in a dark environment at 25±2°C. The values specified are at an approximate distance 50cm from the LCD surface at a viewing angle of Φ and θ equal to 0 ° and aperture 1 degree.

FIG. 1 presents additional information concerning the measurement equipment and method.

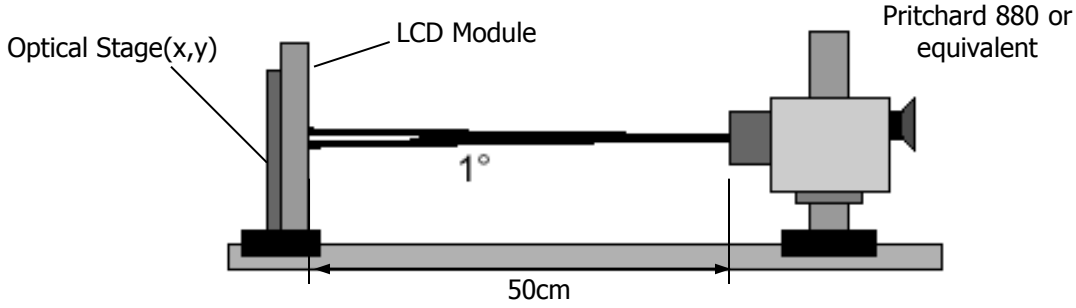


FIG. 1 Optical Characteristic Measurement Equipment and Method

Table 11. OPTICAL CHARACTERISTICS (Ta=25 °C, V_{LCD}=12.0V, f_V=60Hz DCLK=154MHz/2, V_{BR}=3.3V)

Parameter		Symbol	Values			Units	Notes
			Min	Typ	Max		
Contrast Ratio		CR	700	1000	-		1
Surface Luminance, white		L_{WH}	200	250	-	cd/m²	2
Luminance Variation		δ_{WHITE}	80		-	%	3
Response Time	Rise Time	Tr_R	-	6	12	ms	4
	Decay Time	Tr_D	-	6	12		
	Gray to Gray	T_{GTG_AVR}	-	6			5
		T_{GTG_MAX}	-		12	ms	
Color Coordinates [CIE1931]	RED	Rx	Typ -0.03	0.690	Typ +0.03		
		Ry		0.300			
	GREEN	Gx	Typ - 0.045	0.205	Typ + 0.045		
		Gy		0.715			
	BLUE	Bx	Typ -0.03	0.150	Typ +0.03		
		By		0.045			
	WHITE	Wx	Typ -0.03	0.313	Typ +0.03		
		Wy		0.329			
Color Shift	Horizontal	θ_{CST_H}	-	178	-	Degree	6
	Vertical	θ_{CST_V}	-	178	-		
Viewing Angle (CR>10)							
General	Horizontal	θ_H	170	178	-	Degree	7
	Vertical	θ_V	170	178	-		
Effective	Horizontal	θ_{GMA_H}		178	-	Degree	8
	Vertical	θ_{GMA_V}		178	-		
Gray Scale				2.2			9

Notes 1. Contrast Ratio(CR) is defined mathematically as :

$$\text{Contrast Ratio} = \frac{\text{Surface Luminance with all white pixels}}{\text{Surface Luminance with all black pixels}}$$

It is measured at center point1)

2. Surface luminance(L_{WH})is luminance value at center point(1) across the LCD surface 50cm from the surface with all pixels displaying white. For more information see FIG 2.

3. The variation in surface luminance , δ WHITE is defined as :

$$\delta_{WHITE} = \frac{\text{Minimum}(L_{on1}, L_{on2}, \ldots L_{on9})}{\text{Maximum}(L_{on1}, L_{on2}, \ldots L_{on9})} \times 100(\%)$$

Where L1 to L9 are the luminance with all pixels displaying white at 9 locations.
For more information see FIG 2.

4. Response time is the time required for the display to transition from black to white (Rise Time, Tr_R) and from white to black (Decay Time, Tr_D). For additional information see FIG 3.

5. Gray to gray response time is the time required for the display to transition from gray to gray. For additional information see Table 12.

6. Color shift is the angle at which the color difference is lower than 0.04.
For more information see FIG 4.
- Color difference (Δu'v')

$$u' = \frac{4x}{-2x+12y+3} \qquad v' = \frac{9y}{-2x+12y+3}$$

$$\Delta u'v' = \sqrt{(u'_1 - u'_2)^2 + (v'_1 - v'_2)^2}$$

u'1, v'1 : u'v' value at viewing angle direction
u'2, v'2 : u'v' value at front (θ=0)

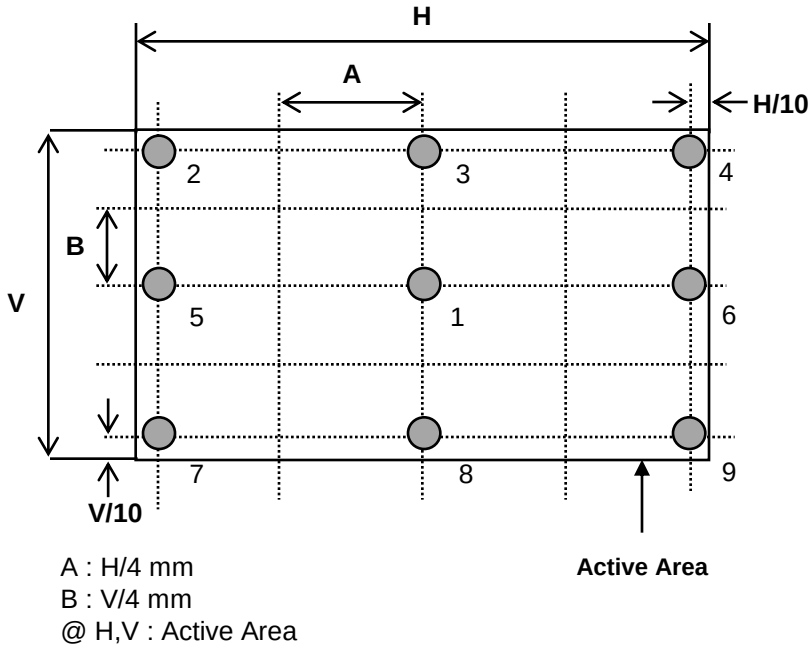
- Pattern size : 25% Box size
- Viewing angle direction of color shift : Horizontal, Vertical

7. Viewing angle is the angle at which the contrast ratio is greater than 10. The angles are determined for the horizontal or x axis and the vertical or y axis with respect to the z axis which is normal to the LCD surface. For more information see FIG 5.

8. Effective viewing angle is the angle at which the gamma shift of gray scale is lower than 0.3.
For more information see FIG 6 and FIG 7.

9. Gray scale specification
Gamma Value is approximately 2.2. For more information see Table 13.

Measuring point for surface luminance & measuring point for luminance variation.



A : H/4 mm
B : V/4 mm
@ H,V : Active Area

FIG. 2 Measure Point for Luminance

The response time is defined as the following figure and shall be measured by switching the input signal for "black" and "white".

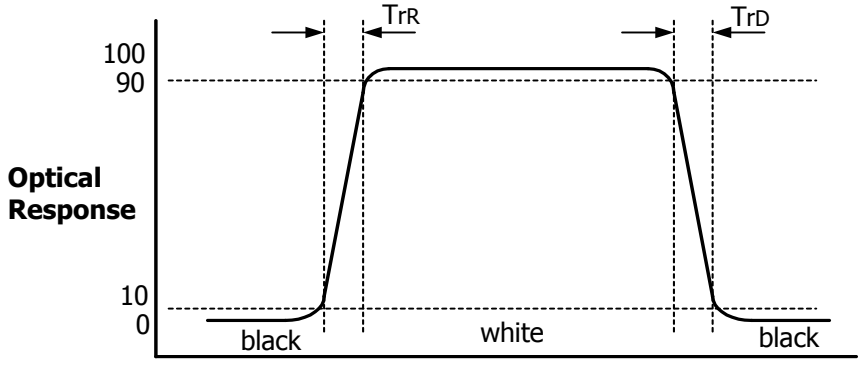


FIG. 3 Response Time

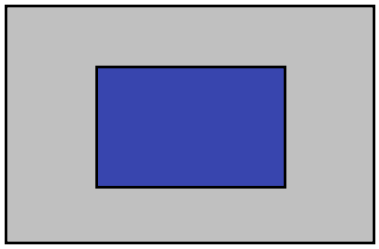
The gray to gray response time is defined as the following figure and shall be measured by switching the input signal for "Gray To Gray".

- Gray step : 5 step
- T_{GTG_AVR} is the total average time at rising time and falling time for "Gray To Gray".
- T_{GTG_MAX} is the max time at rising time or falling time for "Gray To Gray".

Table 12. Gray to gray response time table

Gray to Gray		Rising Time				
		G1023	G767	G511	G255	G0
Falling Time	G1023					
	G767					
	G511					
	G255					
	G0					

Color shift is defined as the following test pattern and color.



25% Box size

FIG. 4 Test Pattern

Average RGB values in Bruce RGB for Macbeth Chart

	Dark skin	Light skin	Blue sky	Foliage	Blue flower	Bluish green
R	395	827	343	311	519	459
G	227	571	451	411	475	799
B	183	495	647	187	743	715
	Orange	Purplish blue	Moderate red	Purple	Yellow green	Orange yellow
R	879	227	847	307	643	923
G	419	279	271	159	775	651
B	99	699	351	347	235	119
	Blue	Green	Red	Yellow	Magenta	cyan
R	107	291	791	967	831	143
G	131	595	111	851	251	507
B	583	263	151	147	607	691
	White	Neutral 8	Neutral 6.5	Neutral 5	Neutral 3.5	black
R	963	827	623	443	255	91
G	963	827	623	443	255	91
B	963	827	623	443	255	91

Dimension of viewing angle range.

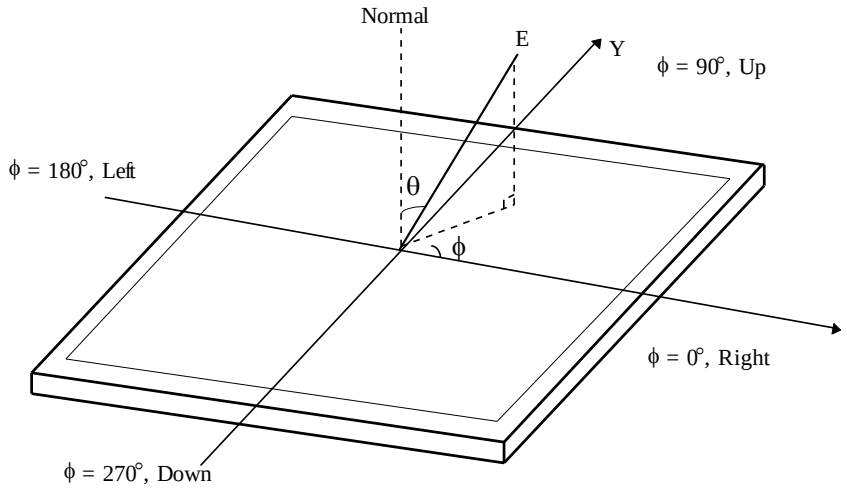


FIG. 5 Viewing angle

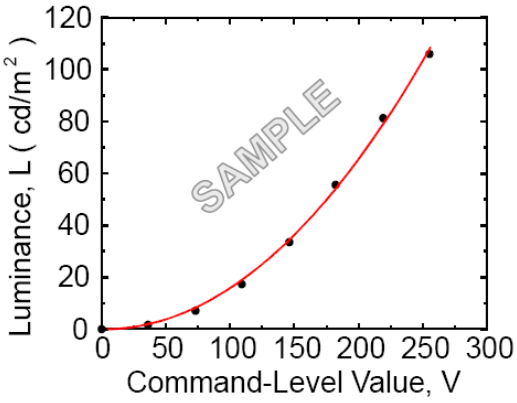


FIG. 6 Sample Luminance vs. gray scale (using a 256 bit gray scale)

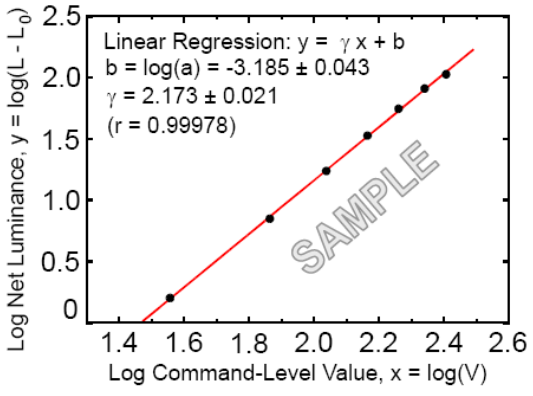


FIG. 7 Sample Log-log plot of luminance vs. gray scale

$$L = aV^{r} + L_b$$

$$\log(L - L_b) = r\log(V) + \log(a)$$

Here the Parameter α and γ relate the signal level V to the luminance L.
The GAMMA we calculate from the log-log representation (FIG. 7)

Table 13. Gray Scale Specification

Gray Level	Relative Luminance [%] (Typ.)
0	0.10
63	0.30
127	1.08
191	2.50
255	4.71
319	7.70
383	11.52
447	16.18
511	21.72
575	28.15
639	35.51
703	43.81
767	53.07
831	63.30
895	74.52
959	86.75
1023	100

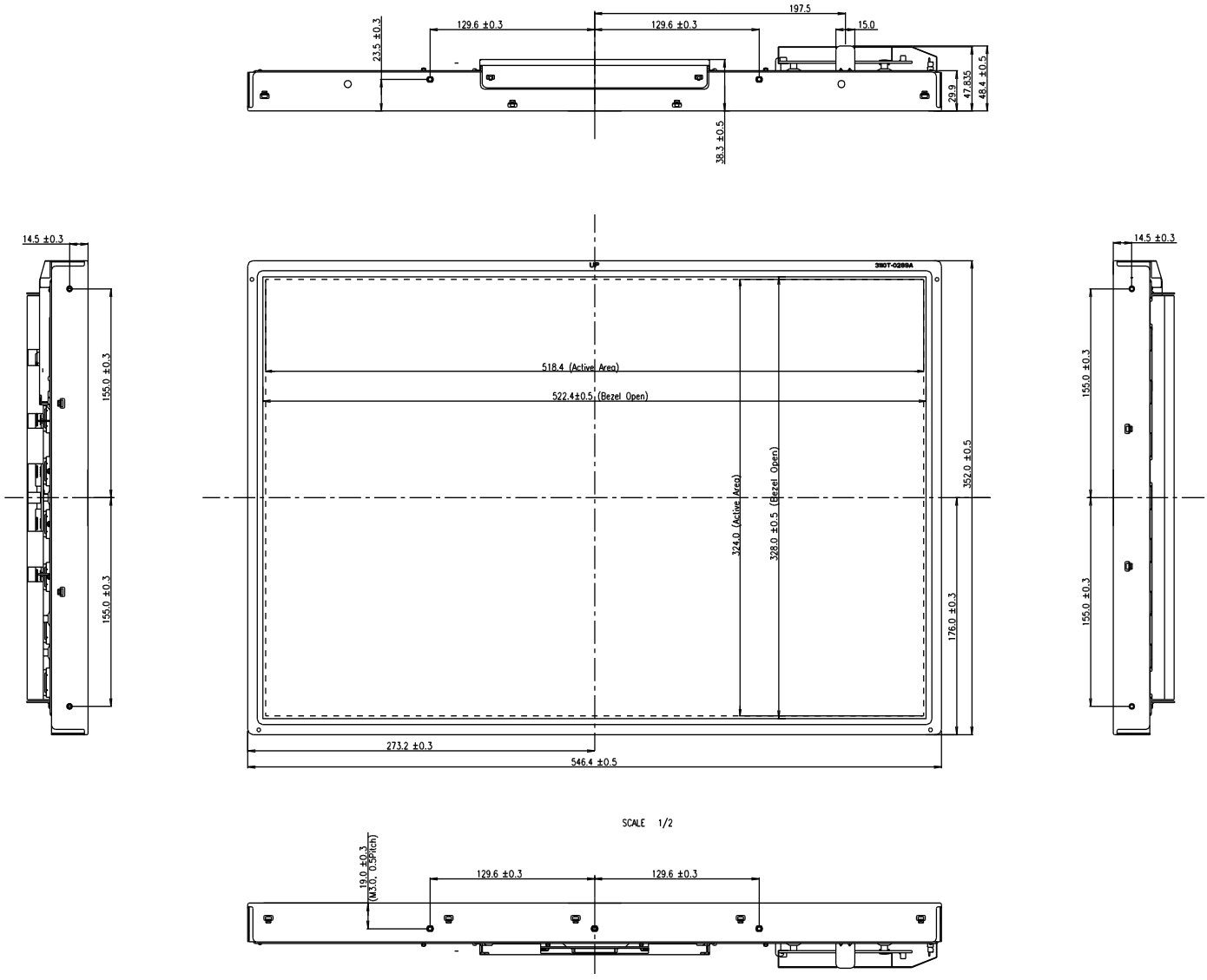
5. Mechanical Characteristics

The contents provide general mechanical characteristics. In addition the figures in the next page are detailed mechanical drawing of the LCD.

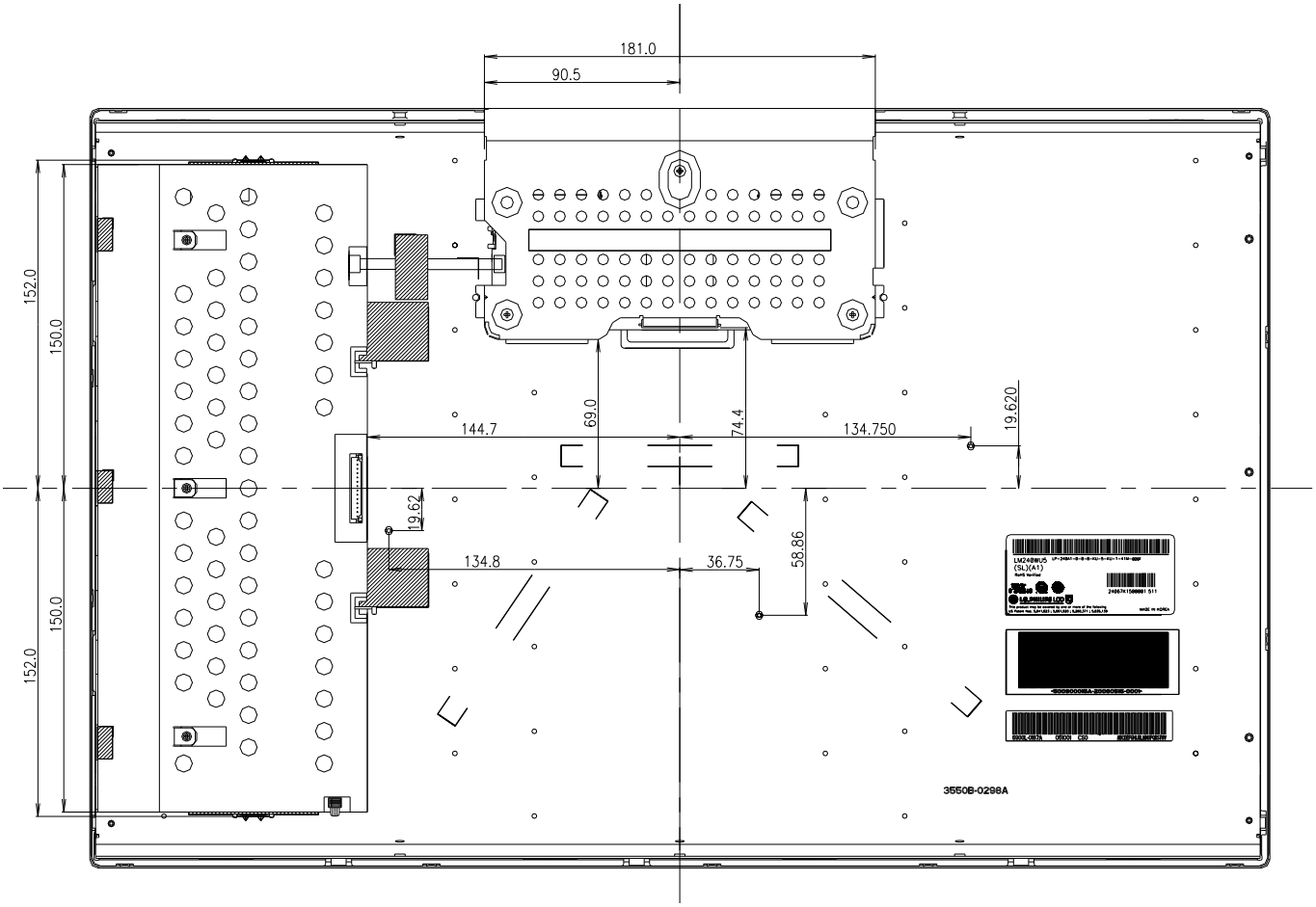
Outline Dimension	Horizontal	546.4mm
	Vertical	352.0mm
	Depth	48.4mm
Bezel Area	Horizontal	522.4mm
	Vertical	328.0mm
Active Display Area	Horizontal	518.4mm
	Vertical	324.0mm
Weight	3,300g (Typ.) / 3,500g (Max.)	
Surface Treatment	Hard coating(3H)	

Notes : Please refer to a mechanic drawing in terms of tolerance at the next page.

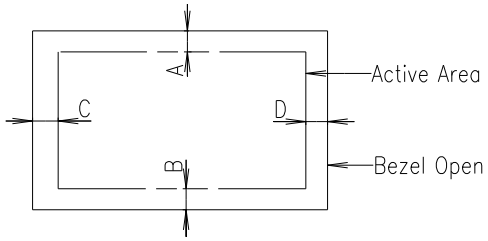
<FRONT VIEW>


197.5
129.6 ±0.3
129.6 ±0.3
15.0
23.5 ±0.3
29.9
47.835
48.4 ±0.5
38.3 ±0.5
14.5 ±0.3
155.0 ±0.3
155.0 ±0.3
UP
3NOT-0288A
518.4 (Active Area)
522.4±0.5 (Bezel Open)
324.0 (Active Area)
328.0 ±0.5 (Bezel Open)
352.0 ±0.5
176.0 ±0.3
273.2 ±0.3
546.4 ±0.5
14.5 ±0.3
155.0 ±0.3
155.0 ±0.3
SCALE 1/2
19.0 ±0.3
(M3.0, 0.5PITCH)
129.6 ±0.3
129.6 ±0.3

<REAR VIEW>



Notes
1. Unspecified tolerances are to be ±1.0mm.
2. Depth of user mounting holes is max 5.0mm
3. Both backlight wires and contraction tubes are excluded from outline dimensions.
4. Tilt and partial disposition tolerance of display area are as following.
   (1) Y-direction : IA-BI < 1.4mm
   (2) X-direction : IA-BI < 1.4mm



5. Torque Spec of User Mounting : 7.0 ~ 8.0kgf cm

6. Reliability

Environment test condition

No	Test Item	Condition
1	High temperature storage test	Ta= 60°C 240h
2	Low temperature storage test	Ta= -20°C 240h
3	High temperature operation test	Ta= 50°C 50%RH 240h
4	Low temperature operation test	Ta= 0°C 240h
5	Vibration test (non-operating)	Wave form : random Vibration level : 1.0G RMS Bandwidth : 10-300Hz Duration : X,Y,Z, 10 min One time each direction
6	Shock test (non-operating)	Shock level : 100Grms Waveform : half sine wave, 2ms Direction : ±X, ±Y, ±Z One time each direction
7	Altitude Operating Storage / Shipment	 0 - 10,000 feet(3,048m) 0 - 40,000 feet(12,192m)

7. International Standards

7-1. Safety

a) UL 60950-1:2003, First Edition, Underwriters Laboratories, Inc.,
Standard for Safety of Information Technology Equipment.
b) CAN/CSA C22.2, No. 60950-1-03 1st Ed. April 1, 2003, Canadian Standards Association,
Standard for Safety of Information Technology Equipment.
c) EN 60950-1:2001, First Edition,
European Committee for Electrotechnical Standardization(CENELEC)
European Standard for Safety of Information Technology Equipment.
d) IEC 60950-1:2001, First Edition, The International Electrotechnical Commission (IEC)
Standard for Safety of Information Technology Equipment.
(Including report of IEC60825-1 Ed. 1.2 2001, clause 8 and clause 9)

Notes

1. Laser (LED Backlight) Information

Class 1 Laser test IEC60825-1: 2001 Embedded LED Power (Class2) Power: 2.01mW (Max.) Wavelength: 452 ~ 630(nm) Width: 0.355~1.46(mm)

2. Caution
: LED Lamp inside.
Class 2 laser (LEDs) radiation when open.
Do not open while operating.

7-2. EMC

a) ANSI C63.4 “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electrical Equipment in the Range of 9kHZ to 40GHz. “American National Standards Institute(ANSI), 1992
b) CISPR22 “Limits and Methods of Measurement of Radio Interface Characteristics of Information Technology Equipment.“ International Special Committee on Radio Interference.
c) EN 55022 “Limits and Methods of Measurement of Radio Interface Characteristics of Information Technology Equipment.“ European Committee for Electrotechnical Standardization.(CENELEC), 1998
(Including A1: 2000)

8. Packing

8-1. Designation of Lot Mark

a) Lot Mark

A	B	C	D	E	F	G	H	I	J	K	L	M

A,B,C : SIZE(INCH)
D : YEAR
E : MONTH
F ~ M : SERIAL NO.

Note

1. YEAR

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Mark	1	2	3	4	5	6	7	8	9	0

2. MONTH

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mark	1	2	3	4	5	6	7	8	9	A	B	C

b) Location of Lot Mark

Serial No. is printed on the label. The label is attached to the backside of the LCD module.
This is subject to change without prior notice.

8-2. Packing Form

a) Package quantity in one box : 5 PCS

b) Box Size : 452mm X 376mm X 660mm

9. PRECAUTIONS

Please pay attention to the followings when you use this TFT LCD module.

9-1. MOUNTING PRECAUTIONS

(1) You must mount a module using holes arranged in four corners or four sides.
(2) You should consider the mounting structure so that uneven force (ex. Twisted stress) is not applied to the module. And the case on which a module is mounted should have sufficient strength so that external force is not transmitted directly to the module.
(3) Please attach the surface transparent protective plate to the surface in order to protect the polarizer. Transparent protective plate should have sufficient strength in order to the resist external force.
(4) You should adopt radiation structure to satisfy the temperature specification.
(5) Acetic acid type and chlorine type materials for the cover case are not desirable because the former generates corrosive gas of attacking the polarizer at high temperature and the latter causes circuit break by electro-chemical reaction.
(6) Do not touch, push or rub the exposed polarizers with glass, tweezers or anything harder than HB pencil lead. And please do not rub with dust clothes with chemical treatment.
Do not touch the surface of polarizer for bare hand or greasy cloth.(Some cosmetics are detrimental to the polarizer.)
(7) When the surface becomes dusty, please wipe gently with absorbent cotton or other soft materials like chamois soaks with petroleum benzene. Normal-hexane is recommended for cleaning the adhesives used to attach front / rear polarizers. Do not use acetone, toluene and alcohol because they cause chemical damage to the polarizer.
(8) Wipe off saliva or water drops as soon as possible. Their long time contact with polarizer causes deformations and color fading.
(9) Do not open the case because inside circuits do not have sufficient strength.

9-2. OPERATING PRECAUTIONS

(1) The spike noise causes the mis-operation of circuits. It should be lower than following voltage :
V=±200mV(Over and under shoot voltage)
(2) Response time depends on the temperature.(In lower temperature, it becomes longer.)
(3) Brightness depends on the temperature. (In higher temperature, it becomes lower.)
(4) Be careful for condensation at sudden temperature change. Condensation makes damage to polarizer or electrical contacted parts. And after fading condensation, smear or spot will occur.
(5) When fixed patterns are displayed for a long time, remnant image is likely to occur.
(6) Module has high frequency circuits. Sufficient suppression to the electromagnetic interference shall be done by system manufacturers. Grounding and shielding methods may be important to minimized the interference.
(7) Please do not give any mechanical and/or acoustical impact to LCM. Otherwise, LCM can't be operated its full characteristics perfectly.
(8) A screw which is fastened up the steels should be a machine screw.
(if not, it causes metallic foreign material and deal LCM a fatal blow)
(9) Please do not set LCD on its edge.

9-3. ELECTROSTATIC DISCHARGE CONTROL

Since a module is composed of electronic circuits, it is not strong to electrostatic discharge. Make certain that treatment persons are connected to ground through wrist band etc. And don't touch interface pin directly.

9-4. PRECAUTIONS FOR STRONG LIGHT EXPOSURE

Strong light exposure causes degradation of polarizer and color filter.

9-5. STORAGE

When storing modules as spares for a long time, the following precautions are necessary.

(1) Store them in a dark place. Do not expose the module to sunlight or fluorescent light. Keep the temperature between 5°C and 35°C at normal humidity.
(2) The polarizer surface should not come in contact with any other object.
It is recommended that they be stored in the container in which they were shipped.

9-6. HANDLING PRECAUTIONS FOR PROTECTION FILM

(1) The protection film is attached to the bezel with a small masking tape.
When the protection film is peeled off, static electricity is generated between the film and polarizer.
This should be peeled off slowly and carefully by people who are electrically grounded and with well ion-blown equipment or in such a condition, etc.
(2) When the module with protection film attached is stored for a long time, sometimes there remains a very small amount of glue still on the bezel after the protection film is peeled off.
(3) You can remove the glue easily. When the glue remains on the bezel surface or its vestige is recognized, please wipe them off with absorbent cotton waste or other soft material like chamois soaked with normal-hexane.